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A STUDY OF THE LEAF CUTICLE OF INDIAN *CLEMATIS* (DILL. EX) LINN. (RANUNCULACEAE)

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ABSTRACT

The paper appraises the characteristics of leaf cuticle of 40 taxa of *Clematis*, representing 32 species. The cuticular features exhibit a reticulate pattern with little correlation with arrangement as projected by gross-morphological features. Nevertheless, these do provide characters of systematic value to be taken use of in distinguishing the various taxa.

INTRODUCTION

The importance of cuticular features in taxonomy and phylogenetic considerations has been well demonstrated time and again.

Kapoor (1958a, b, 1962, 1965, 1966, 1969, 1983) studied the Indian *Clematis* for a taxonomic revision utilising, besides gross morphological characters, the cuticular and pollen features also.

In this work the characteristics of the leaf cuticle of 40 taxa belonging to *Clematis* (34 occurring within the present-day boundaries of India, 1 cultivated in Indian gardens and 5 occurring outside India but having bearing on taxonomy of Indian *Clematis*), representing 32 species, have been presented with appraisal of their taxonomic significance. The synopsis (Table 1) includes data on *Naravelia zeylanica* (Linn.) DC. also, a closely related taxon.

MATERIAL AND METHODS

The material was procured from different herbaria as cited, along with details, under each taxon. As far as possible 1 × 1 cm pieces of lamina were cut from each leaf from middle region including midrib and from marginal regions excluding midrib. These were soaked in warm water for 15 minutes to enable tissues to swell to normal and then placed in maceration mixture composed of 10% chromic acid and concentrated nitric acid, in equal parts. Macerated pieces were thoroughly washed with water and treated with dilute ammonium hydroxide to dissolve the oxidised tissues between adaxial and abaxial epidermis. The two layers were carefully separated with the help of needles, cleaned, and washed with water. Two stains were used for staining : 1. Sudan IV, 2. aqueous safranin 1%. The stained cuticles were mounted in pure glycerine followed by sealing with Canada balsam or wax.

OBSERVATIONS

The salient cuticular features are presented in Table 1 to enable visual comparison, and the details are described below; the taxa are arranged section-wise according to Tamura's (1956, 1967) classification of *Clematis*.

Section *Viorna* (Reichb.) Prantl subsection *Connatae* Koehne

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Date of receipt : 7.10.85. Date of acceptance : 5.12.86

Clematis connata DC. *Prodr.* 1 : 4. 1824.

(Between Rielkot and Bagudiar, Almora, 13.11.1958, *J. G. Srivastava 53567, 53583*, LWG).

Epidermal cells on adaxial surface polygonal to irregular, at places hexagonal ; on abaxial surface irregular, sinuous.

Stomata confined to abaxial surface, irregularly arranged, anomocytic, at places paracytic, 1 to 2 cells apart, quite large, twin stomata observed at places, 30-34-36 × 12-14-17 μm, stomatal index 22-26-29, frequency of stomata 135 per sq. mm.

Trichomes on both the surfaces, abundant on veins, small, papillae-like, bases small, round.

Clematis acuminata DC. *Syst.* 1 : 148. 1818.

Clematis acuminata subsp. **acuminata**
(*Gamble 27451*, acc. no. 454, CAL).

Epidermal cells on adaxial surface polygonal, straight-walled ; on abaxial surface (fig. 17) highly irregular, sinuous.

Stomata confined to abaxial surface, sparsely distributed, anomocytic, 26-32-36 × 10-12-13 μm, stomatal index 26-29-35, frequency of stomata 150 per sq. mm.

Trichomes on both surfaces on veins, long or short, sparsely distributed ; bases hexagonal.

Clematis acuminata subsp. **sikkimensis** (Hk. f. et Thoms.) Brühl *Ann. Roy. bot. Gdn. Calc.* 5(2) : 75. 1896 (excl. var. *andersonii*).

Clematis acuminata subsp. **sikkimensis** var. **sikkimensis**
(On way to Rewa, Madhya Pradesh, 14.12.1953, *Kaul & Party 5058*, acc. no. 53149, LWG).

Epidermal cells on adaxial surface polygonal, straight-walled ; on abaxial surface irregular, sinuous.

Stomata confined to abaxial surface, 4-5 cells apart, anomocytic, 26-29-33 × 10-13-17 μm, stomatal index 27-29-35, frequency of stomata 141 per sq. mm.

Trichomes on upper surface, few, restricted to veins.

Clematis acuminata subsp. **andersonii** (Brühl) Kapoor, *Bull. nat. bot. Gdn. Luck.* 124 : 10-11. 1966.

(Yunnan, 1875, *D. J. Anderson 1811*, acc. no. 470, CAL).

Epidermal cells on adaxial surface polygonal, straight-walled ; on abaxial surface irregular, sinuous.

Stomata confined to abaxial surface, irregularly distributed, anomocytic, 2 to 3 cells apart, at places giant stomata observed (fig. 24), generally 23-28-33 × 10-11-13 μm, stomatal index 22-24-29, frequency of stomata 106 per sq. mm.

Trichomes on both surfaces, usually on the veins, long or short, unicellular.

Clematis roylei Rehd. in *J. Arn. Arb.* 22 : 575. 1941.

Clematis roylei var. **roylei**
(*G. S. Puri 10151*, BSI).

Epidermal cells on adaxial surface polygonal, straight-walled ; on abaxial surface irregular, slightly sinuous.

Stomata confined to abaxial surface, irregularly and compactly arranged, anomocytic, 23-28-33 × 7-9-12 μm, stomatal index 28-31-33, frequency of stomata 164 per sq. mm.

Trichomes on adaxial surface numerous on veins and general surface, long, unicellular, apex usually pointed, base hexagonal, slightly thickened, on abaxial surface more abundant than on upper.

Clematis roylei var. **patens** (Haines) Kapoor, *Bull. nat. bot. Gdn. Luck.* 124 : 63-65. t. 4. 1966.

(Sundi Buru, Singbhum, 750 m, 27.11.1902, *H. H. Haines, s.n.,* acc. no. 86707, MH).

Epidermal cells on both surfaces similar as seen in var. *roylei.*

Stomata relatively sparsely distributed as compared to var. *roylei,* otherwise similar, 23-28-33 × 10-12-13 μ m, stomatal index 29-31-33, frequency of stomata 160 per sq. mm.

Trichomes on both the surfaces, longer than those on corresponding surfaces in var. *roylei,* otherwise similar.

Clematis wattii Drummond et Craib, *Kew Bull.* 1915 : 421. 1915.

(Tider Ngingzon, Chin Hills, Burma, 21.12.52, *Po Khant 2659,* DD).

Epidermal cells on adaxial surface penta- or hexa-gonal, straight-walled, on abaxial surface irregular, slightly sinuous.

Stomata confined to abaxial surface, irregularly distributed, 3-4 cells apart, mostly anomocytic, 30-32-36 × 12-14-17 μ m, stomatal index 20-25-34, frequency of stomata 122 per sq. mm.

Trichomes numerous on both the surfaces, bases hexagonal.

Clematis tortuosa (Wall. ex Hk. f. & Thoms.) Fischer in *Kew Bull.* 1929 : 4. 1929.

(Darjeeling, *K. Biswas 8711,* acc. no. 2212, LWG).

Epidermal cells on adaxial surface irregular, slightly sinuous ; on abaxial surface irregular, sinuous.

Stomata confined to abaxial surface, irregularly arranged, anomocytic, usually 1 to 2 cells apart, 30-34-36 × 10-14-17 μ m, stomatal index 28-31-36, frequency of stomata 177 per sq. mm.

Trichomes on both the surfaces, long or short, bases hexagonal.

Clematis buchananiana DC. *Syst.* 1 : 140. 1818 (*'buchaniana'*).

(Massoorie, 17.12.1956. *Mahajan 10779,* BSI).

Epidermal cells on adaxial surface polygonal to irregular ; on lower surface irregular, slightly sinuous, striated on both surfaces.

Stomata confined to abaxial surface, irregularly distributed, anomocytic, at places paracytic, 30 × 13 μ m, stomatal index 22-27-33, frequency of stomata 136 per sq. mm.

Striations arising from trichome bases, at places on abaxial surface arising from subsidiary cells.

Trichomes on both surfaces abundant, more so on the veins, unicellular, bases hexagonal, thick-walled.

Clematis grewiiflora DC. *Syst.* 1 : 140. 1818.

Clematis grewiiflora var. **grewiiflora**

(Assam, March 1891, *King's Collector s.n.,* acc. no. 74, BSIS).

Epidermal cells on adaxial surface polygonal to irregular, straight-walled, on abaxial surface irregular, slightly sinuous, occasionally striated on both surfaces.

Stomata confined to abaxial surface, irregularly distributed, anomocytic, rounded, contiguous stomata observed frequently, 26-28-30 × 13-14-15 μ m, stomatal index 26-29-33, frequency of stomata 166 per sq. mm.

Striations arising from trichome bases.

Trichomes numerous, unicellular, long, bases hexagonal, frequently bases united, trichomes on abaxial surface longer and frequency much higher as compared to those on adaxial surface.

Section *Meclatis* (Spach) Tamura subsection *Orientales* Prantl

Clematis orientalis Linn. *Sp. Pl.* 543. 1753.

Clematis orientalis var. **longicaudata** (Ledeb.) Boiss. *Fl. Or.* 1 : 4. 1867 (*'longecaudata'*).

(Tibet, *T. Thomson s, n.,* acc, no, 62615, MH).

Epidermal cells on both surfaces hexa- or penta-gonal, straight-walled, walls thick.

Stomata present on both surfaces, irregularly distributed, anomocytic, frequency much higher on abaxial surface, occasionally one subsidiary cell on one side of stomata distinct whereas rest (on the other side) similar to other epidermal cells (fig. 18), 30-34-36 × 17-19-23 μm, stomatal index on adaxial surface 3-5-7, on abaxial surface 23-26-29, frequency of stomata on adaxial surface 27 per sq. mm. and on abaxial surface 112 per sq. mm.

Trichomes absent.

Clematis orientalis var. **obtusifolia** Hk. f. & Thoms. *Fl. Ind.* 9. 1855.

(Chamba, Punjab, *Lace* 530, acc. no. 58. BSIS).

Epidermal cells on adaxial surface hexa-, penta- or poly-gonal, straight-walled, walls thick ; on abaxial surface irregular, slightly sinuous, at places walls thick.

Stomata present on both surfaces, irregularly distributed, anomocytic ; frequency more on abaxial surface, in some a distinctive subsidiary cell on one side of stomata, at some places more than one subsidiary cells parallel to the stomatal axis on one side of the stomata and on other side subsidiary cells like normal epidermal cells ; contiguous stomata (with one subsidiary cell common to two stomata) seen at places, 30-34-36-40 × 13-18-23 μm, stomatal index on adaxial surface 7-10-11, on abaxial surface 19-22-25, frequency of stomata on adaxial surface 52 per sq. mm. and on lower 105-111 per sq. mm.

Domatia present on abaxial surface.

Trichomes absent.

Clematis graveolens Lindl. in *J. Hort. Soc.* 1 : 207. 1846.

(Sides of ravines, Mashobra, Hazara, 29.9.1889, *Duthie* 7423, acc. no. 1471, BSI).

Epidermal cells on adaxial surface hexa-, or penta-gonal, straight-walled ; on abaxial surface irregular, slightly sinuous.

Stomata confined to abaxial surface, anomocytic, irregularly distributed, 30-33-36 × 17-18-21 μm, stomatal index 14-18-20, frequency of stomata 111 per sq. mm.

Small papillae seen at places on abaxial surface.

Clematis wightiana Wall. (Cat. 4674 *nom. nud.*) ex Wight & Arn. *Prodr.* 1 : 2. 1834.

(Nilgiri, 1860, *H.F.C. Cleghorn s.n.*, acc. no. 58, MH ; *E. Vajravelu 43657*, MH).

Epidermal cells on adaxial surface polygonal, straight-walled ; in *Vajravelu 43657* slightly sinuous (figs. 6 & 16) ; on abaxial surface irregular, slightly sinuous (fig. 11), in *Vajravelu 43657* highly irregular and sinuous, striated on both surfaces.

Stomata confined to abaxial surface, irregularly distributed, anomocytic, at places paracytic, 30-33-36 × 17-20-23 μm, stomatal index 20-24-26, frequency of stomata 161 per sq. mm.

Striations arising from trichome bases, on abaxial surface also originating from guard cells.

Trichomes present on both surfaces, abundant on veins, relatively sparser on general surface, unicellular, long (fig. 6), small papillae also interspersed and distributed throughout the surface, trichome bases hexa- or penta-gonal with slightly thickened wall, at places trichome bases united.

Section *Meclatis* subsection *Tanguticae* Schneider.

Clematis vernayi Fischer, *Kew Bull.* 1937 : 35. 1937.

(Tibet, *T Thoms.* s.n., acc. no. 869, CAL).

Epidermal cells on adaxial surface hexa- or penta-gonal, straight- and thick-walled ; on abaxial surface poly-gonal, straight-walled.

Stomata present on both the surfaces,

irregularly distributed ; frequency more on abaxial surface, anomocytic, in some a prominent distinctive subsidiary cell on one side and normal epidermal cells surrounding stomata on other side, 30-32-33 × 17-20 μm, stomatal index on adaxial surface 10-12-13 and on abaxial surface 19-21-23, frequency of stomata on adaxial surface 54 per sq. mm. and on abaxial surface 94 per sq. mm.

Domatia present on abaxial surface.

Minute papillae at places on abaxial surface, bases small, round.

Section *Bebaenthera* Edgew.

Clematis acutangula Hk. f. et Thoms. *Fl. Ind.* 1 : 5. 1855.

(Rupa and surroundings, 30.9.1964, *J. Joseph 40385,* ASSAM).

Epidermal cells on both surfaces irregular, sinuous.

Stomata confined to abaxial surface, anomocytic, outer wall of guard cells usually thickened, twin stomata observed at places, 30-32-33 × 17-20 μm, stomatal index 33-35-37, frequency of stomata 205 per sq. mm.

Trichomes on adaxial surface on veins, scattered, quite long with pointed ends, unicellular, base hexagonal, small ; on abaxial surface at places, small, unicellular, papillae-like with rounded apex.

Clematis barbellata Edgew., in *Trans. Linn. Soc.* 20 : 25. 1851.

Clematis barbellata var. **barbellata**

(Kaul & Party 48275, LWG).

Masobra, 15 miles from Simla, Himachal Pradesh, 25.9.1968.

Epidermal cells irregular, on adaxial surface slightly sinuous, on abaxial surface slightly (more than the adaxial ones) sinuous.

Stomata confined to abaxial surface, anomocytic, 3 to 4 cells apart (distantly scattered on surface) 30-32-33 × 12-14-17 μm, stomatal index 14-17-22, frequency of stomata 71 per sq. mm.

Section *Cheiropsis* DC.

Clematis napaulensis Wall. (Cat. 4680, *nom. nud.*) ex DC. *Syst.* 1 : 164. 1818.

(Deoban, 25.4.22, *Jog Dhyan Sharma s.n.,* acc. no. 5274, BSI).

Epidermal cells on adaxial surface small, irregular, smooth-walled ; on abaxial surface irregular, slightly sinuate.

Stomata confined to abaxial surface mostly anomocytic, at places paracytic, 17-18-20 × 10-11-13 μm (some about half of the normal ones), stomatal index 33-35-37, frequency of stomata 218 per sq. mm.

Striations at places observed arising from subsidiary cells.

Trichomes short, unicellular, base rounded, on adaxial surface confined mostly on veins, on abaxial surface frequency higher.

Clematis montana Buch.-Ham. ex DC. *Syst.* 1 : 164. 1818.

Clematis montana ssp. **montana** var. **montana**

(N.W. Himalaya, 180-300 m, *T. Thoms. s.n.,* acc. no. 62604, MH ; Liddar Valley, Kashmir, 10.5.1900, *s.l. 4223,* acc. no. 1469. BSI).

Epidermal cells on adaxial surface penta-, or hexa-gonal, thick-walled, walls smooth, faintly striated ; on abaxial surface polygonal, smooth-walled, heavily striated (fig. 25), cells on veins elongated, striations parallel in direction of veins.

Stomata confined to abaxial surface, anomocytic and paracytic, at places more than 2 subsidiary cells parallel to stomatal apparatus (brachyparacytic), twin stomata occasionally present, contiguous laterally, 33-34-36 × 17-18-20 μm, stomatal index 16-18-20, frequency of stomata 74 per sq. mm.

Striations on abaxial surface arising either from subsidiary cells or in some cases from guard cells on external face.

Clematis montana ssp. **montana** var. **manipurensis** Brühl. *Ann. Roy Bot. Gdn.* 5(2) : 74. t. 103. f. 3. 1896.

(Sirohifurar, Manipur, 12.4.82, *George Watt. s.n.*, acc. no. 62599, MH).

Epidermal cells on both surfaces irregular, slightly sinuous, walls slightly thickened; abaxial surface commonly striated.

Stomata confined to abaxial surface, paracytic, occasionally anomocytic, 26-28-29 × 13-14-17 μm, stomatal index 24-26-28, frequency of stomata 107 per sq. mm.

Striations arising from subsidiary cells.

Trichomes short, glandular, bases small, hexagonal; on adaxial surface mostly on veins, on abaxial surface only on veins.

At places on adaxial surface domatia present.

Clematis montana ssp. **praecox** Ktze. *Verh. bot. Ver. Brandenb.* 26 : 142. 1885 (incl. var. **herbacea**).

(Bijani, *King's collector 1888*, acc. no. 626, CAL; On way to Phalut, Distt. Darjeeling, 29.5.1962, *S. P. Bhatnagar & Party 73614*, LWG).

Epidermal cells irregular, slightly sinuous, on adaxial surface large, rarely elongated.

Stomata confined to abaxial surface, paracytic, scattered, almost of uniform size, at places twin stomata observed, contiguous laterally, 26-28-30 × 12-13 μm, stomatal index 26-28-30, frequency of stomata 144 per sq. mm.

Trichomes on adaxial surface numerous on veins and scattered all over surface, short as well as long, trichome bases small, rounded; on abaxial surface mostly short.

Clematis fasciculiflora Franchet, Pl. Delav. 1 : 5. 1889.

(Yunnan, China, *George Forest 471*, CAL).

Epidermal cells irregular, on adaxial surface slightly sinuous, on abaxial surface sinuous, those near veins striated.

Stomata confined to abaxial surface, anomocytic, 3 to 4 cells, apart, those near veins slightly elongated, 33-38-43 × 12-14-17 μm, stomatal index 20-22-24, frequency of stomata 97 per sq. mm.

Striations arising from guard cells.

Clematis tongluensis (Brühl) Tamura, *Acta Phytotax. Kyoto* 19 (2-3) : 77. 1962.

Clematis tongluensis var. **tongluensis**

(Tonglu, Darjeeling, 3000 m, July 1881, *Gamble* 9442, acc. no. 62601, MH).

Epidermal cells on adaxial surface penta-, hexa-, or poly-gonal, thick-walled, walls arched or straight; on abaxial surface usually polygonal, straight-walled, at places striated.

Stomata confined to abaxial surface, usually anomocytic, occasionally paracytic, 26-28-30 × 12-14-17 μm, stomatal index 19-22-24.

Striations arising from guard cells.

Trichomes on adaxial surface on veins, scattered, base rounded, one-celled, broad, apex rounded; on abaxial surface unicellular, papillae-like, scattered all over surface.

Section *Clematis* subsection *Pierotianae* (Tamura) Tamura.

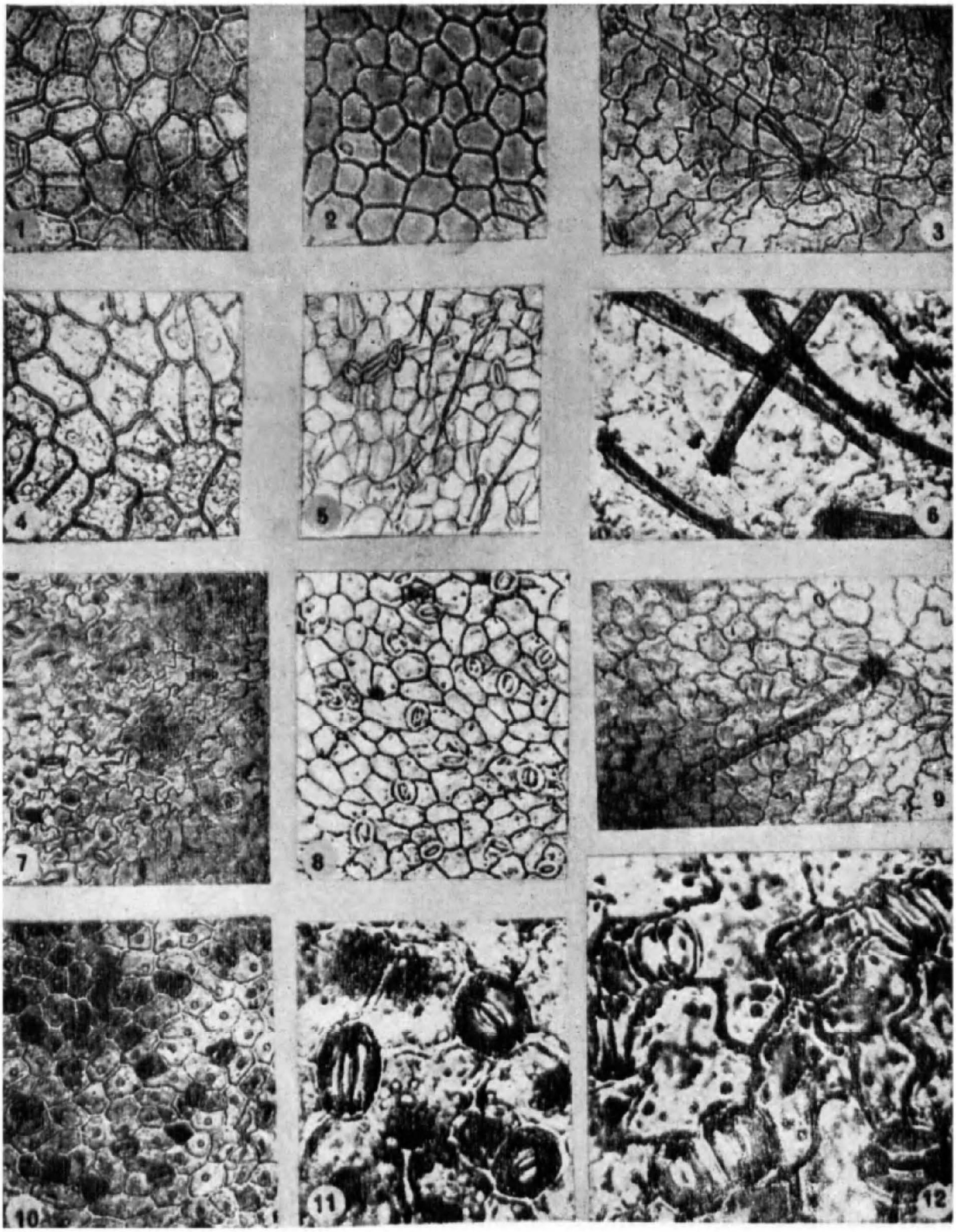
Clematis flammula Linn. *Sp. Pl.* 766. 1753.

(National Botanic Gardens, Lucknow, cultivated, 6.6.1957, *A. L. Gupta 7313*, LWG).

Epidermal cells on adaxial surface usually polygonal, smooth-walled, walls slightly thickened; on abaxial surface polygonal, slightly sinuous.

Stomata confined to abaxial surface, anomocytic, at places cytoplasmic connection either side to side (fig. 22), or end to end and twin stomata observed, more or less of uniform size, 26-30-33 × 17-18-20 μm, a few quite large (36-38-40 × 23-24-26 μm), stomatal index 24-26-28, frequency of stomata 106 per sq. mm.

Clematis triloba Heyne in Roth *Nov. Sp.* 251. 1821. (Katraz Ghat, Pune, 18.10.58,



Figs. 1-12 : 1. *C. hedysarifolia*, epidermal cells on adaxial surface straight-walled × 108. 2. *C. smilacifolia* subsp. *smilacifolia* var. *smilacifolia*, epidermal cells on adaxial surface straight-walled or walls arched × 108. 3. *C. hedysarifolia*, epidermal cells on abaxial surface sinuous × 108. 4. *C. hedysarifolia*, epidermal cells on adaxial surface irregular and slightly sinuous × 108. 5. *C. asplenifolia*, stomata on adaxial surface × 108. 6. *C. wightiana*, epidermal cells on adaxial surface slightly sinuous × 108. 7. *C. grata*, epidermal cells on abaxial surface sinuous × 108. 8. *C. asplenifolia*, epidermal cells on abaxial surface straight-walled × 108. 9. *C. grata*, epidermal cells on adaxial surface irregular and slightly sinuous × 108. 10. *C. gouriana*, epidermal cells on abaxial surface straight-walled × 108. 11. *C. wightiana*, epidermal cells on abaxial surface slightly sinuous × 216. 12. *C. gouriana*, epidermal cells on abaxial surface sinuous, contiguous stomata present × 216.

S. C. Tavakari T2058, BLAT; Agumbe, Karnataka, 18.10.1962, *R. Sundara Raghavan 83326,* acc. no. 81805, BSI).

Epidermal cells on adaxial surface polygonal or irregular, smooth-walled; on abaxial surface irregular, slightly sinuous, at places striated.

Stomata confined to abaxial surface, anomocytic, evenly distributed. 2-4 cells apart, twin stomata coherent by polar region observed at places, 33-38-43 × 20-23-26 μm, stomatal index 24-26-29, frequency of stomata 112 per sq. mm.

Striations on abaxial surface arising from guard cells.

Trichomes on adaxial surface distributed sparsely throughout, frequency higher on veins, long, unicellular, bases small, circular, thick-walled; on abaxial surface as described above, besides large trichomes there are small papillae-like trichomes, one cell thick, distributed all over surface, bases of papillar trichomes very small.

Section *Clematis* subsection *Vitalbae* (Prantl) Tamura

Clematis puberula Hk. f. & Thoms. in Hk. f. *Fl. Brit. Ind.* 1 : 4. 1872.

(*Clarke 40560B,* acc. no. 329, CAL)

Epidermal cells on both surfaces irregular, slightly sinuous.

Stomata confined to abaxial surface, anomocytic, at places paracytic, sparsely distributed, 23-29-36 × 10-12-13 μm, stomatal index 15-21-26, frequency of stomata 106 per sq. mm.

Trichomes present on both surfaces but less frequent on abaxial, unicellular, short, bases hexagonal, thick-walled.

Clematis grata Wall. (*Cat. 4668 nom. nud.*) *Pl. Asiat. Rar.* 1 : 83. t. 98. 1830.

(Monali-nagar, Lahul, 2250 m, 23.7.1938, *N. L. Bor s.n.,* BLAT; Simla, 20.4.1831, *Lady Dalhousie s.n.,* acc. no. 62610, MH; Vaishno Devi Hills, Jammu-Kashmir, 10.7.1963, *K. N. Kaul & Party, 86522,* LWG).

Epidermal cells on adaxial surface quite irregular, slightly sinuous (fig. 9); on abaxial surface irregular, sinuous (fig. 7), at places striated.

Stomata confined to abaxial surface, anomocytic, 1 to 2 cells apart (fig. 7), 30-40-46 × 17-19-21 μm, stomatal index 36-39-42, frequency of stomata 284 per sq. mm.

Striations emanate from guard cells and trichome bases.

Trichomes on adaxial surface sparsely distributed all over surface; numerous on veins, long, unicellular (fig. 9), bases hexagonal, thick-walled, small one-celled papillae interspersed with long trichomes throughout the surface; on abaxial surface long trichomes present on veins, short ones distributed throughout the surface, bases hexagonal.

C. vitalba Linn. Sp. Pl. 1 : 544. 1753.

Epidermal cells on both the surfaces irregular, sinuous, on the veins elongated, smooth-walled, striated on abaxial surface.

Stomata confined to abaxial surface, anomocytic, 3-4 cells apart, outer wall of guard cells thickened, stomata on the veins elongated with collapsed guard cells, 30-34-40 × 15-17-20 μm, stomatal index 19-25-30, frequency of stomata 121 per sq. mm.

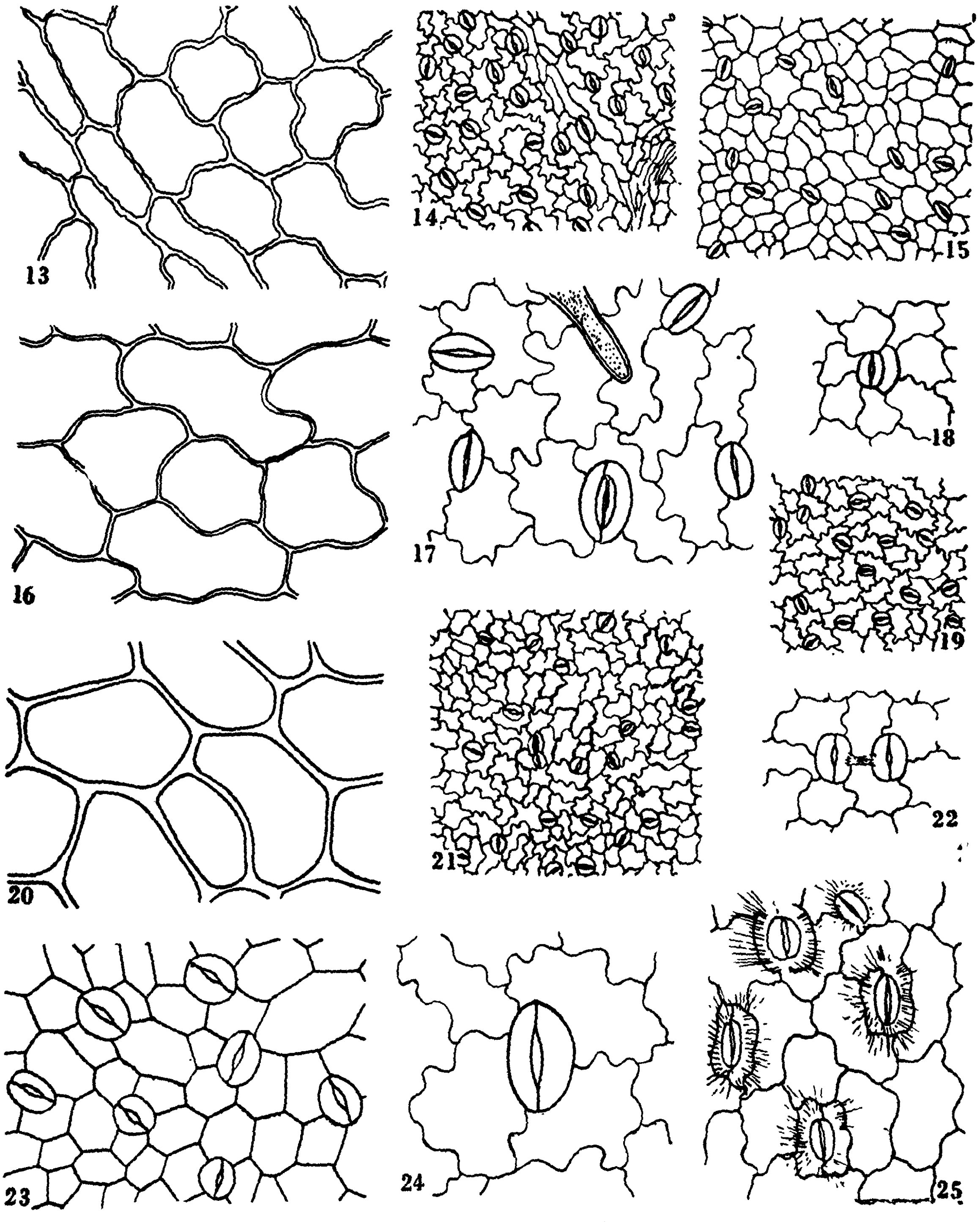
At places striations arising from guard cells.

Trichomes on adaxial surface, small, papillae-like, present sparsely and only on the larger veins.

Clematis gouriana Roxb. (*Cat. Hort. Beng.* 43. 1814 *nom. nud.*; Wall. *Cat. 4673 nom. nud.*) ex DC. Syst. 1. 138. 1818.

(Coonoor to Burlyar, Dec. 30, *Barber 5391,* MH; Slopes below Vazirgadh Fort, 29.12.1945, *H. Santapau 8332,* BLAT; *s.l. coll. no. 39717,* MH).

Epidermal cells on adaxial surface irregular, slightly sinuous (fig. 13); on abaxial



Figs. 13-25 : 13. *C. gouriana*, epidermal cells slightly sinuous × 130. 14. *C. hedysarifolia*, epidermal cells on abaxial surface sinuous ×67. 15. *C. theobromina*, epidermal cells on abaxial surface straight-walled ×67. 16. *C. wightiana*, epidemal cels on adaxial surface slightly sinuous × 130. 17. *C. acuminata* subsp. *acuminata*, epidermal cells on abaxial surfacesinuous × 130. 18. *C. orientalis* var. *longicaudata*, stomata with one subsidiary cell different from the rest × 130. 19. *C. smilacifolia* subsp. *andamanica*, epidermal cells on abaxial surface sinuous ×67. 20. *C. theobromina*, epidermal cells on adaxial surface straight-walled, walls thick × 130. 21. *C. hedysarifolia*, epidermal cells on abaxial surfacesinuous, stomata cohering pole to pole ×67. 22. *C. flammula*, cytoplasmic connection between the stomata on abaxial surface × 130. 23. *C. gouriana*, epidermal cells on abaxial surface straiget-walled × 130. 24. *C. acuminata* subsp. *andersonii*, giant stomata on abaxial surface × 130. 25. *C. montana* subsp. *montana* var. *montana*, epidermal cells on obaxial surface with paracytic stomata, striations arising from subsidiary cells × 130.

surface variable : in *Barber 5391* cells irregular, large, sinuous (fig. 12), in *coll. no. 39717* polygonal, smaller, straight-walled (figs. 10 & 23) or slightly sinuous, in *H. Santapau 8332* large, highly sinuous.

Stomata confined to abaxial surface, anomocytic, contiguous stomata observed, frequency and size variable : in *Barber 5391* stomata 1 to 2 cells apart (14-17 in the microscopic field), in *coll. no. 39717* smaller (22-26 in microscopic field), and in *H. Santapau 8332* large (10-14 in microscopic field), generally 30-32-36 × 13-15-17 μm, stomatal index 21-23-26, frequency of stomata 125 per sq. mm.

Trichomes on abaxial surface numerous on veins, long, unicellular, bases small, rounded.

Clematis kerriana Drumm. et Craib, *Kew Bull.* 1914 : 122. 1914.

(*O. Riley 1887*, acc. no. 324, CAL ; *Collett 1887*, acc. no. 314, CAL).

Epidermal cells on adaxial surface penta- to hexa-gonal, at places irregular, slightly sinuous ; on abaxial surface irregular, sinuous.

Stomata confined to abaxial surface, anomocytic, 26-29-31 × 10-11-13μm, stomatal index 37-41-46, frequency of stomata 217 per sq. mm.

Trichomes on both surfaces, more abundant on veins, unicellular, long, or short papillae-like, base hexagonal, thick-walled.

Note : *Collett 1887* has stomatal frequency low (12-15 stomata in the microscopic field), stomata smaller ; *Riley 1887* has stomatal frequency high (25-30 stomata in the microscopic field), stomata larger.

Clematis apiculata Hk. f. & Thoms. in Hk. f. *Fl. Brit. India* 1 : 4. 1872.

[Khasi Hills, *Botanical Garden Collector s.n.* (presented by Dr. King 1882), DD].

Epidermal cells on adaxial surface hexa-, or penta-gonal, small, straight-walled ; on abaxial surface irregular, slightly sinuous.

Stomata confined to abaxial surface, irregularly distributed, anomocytic, 2-3 cells apart, 26-29-30 × 10-13-15 μm, stomatal index 24-27-32, frequency of stomata 129 per sq. mm.

Trichomes unicellular, long, on adaxial surface on the veins, on abaxial surface common on entire surface.

Sect. *Clematis* subsect. *Rectae* Prantl

Clematis asplenifolia Schrenk, *Enum. Pl. Nov. Alt.* 68. Boiss. *Fl. Or.* 1 : 3. 1867.

(Gilgit, South of Hindukush, *G. M. Giles 1885*, acc. no. 610, CAL).

Epidermal cells on both surfaces hexa-, or penta-gonal, straight-walled (figs. 5 & 8).

Stomata present on both surfaces, irregularly distributed, anomocytic, 4-5 cells apart on adaxial surface and 2-3 cells apart on abaxial surface, on adaxial 33 × 26 μm, on abaxial 30-34-36 × 13-15-17 μm, contiguous stomata observed, stomatal index on adaxial surface 8-11-14, on abaxial surface 19-23-27, frequency of stomata on adaxial surface 39 per sq. mm. and on abaxial 80-120 per sq. mm.

Trichomes absent.

Section *Naraveliopsis* Hand.-Mzt.

Clematis hedysarifolia DC. Syst. 1 : 148. 1818.

[Gira Hill, Khandala, Oct. 1918, *H. Santapau 27623*, BLAT ; Pune-Bhimshankar Road (71st mile), 8.10.1962, *K. P. Janardhanan 81694*, acc. no. 49053, BSI].

Epidermal cells thick-walled, on adaxial surface penta-, or hexa-gonal, straight-walled in *H. Santapau 27623* (fig. 1), irregular and slightly sinuous in *Janardhanan 81694* (fig. 4) ; on abaxial surface irregular, sinuous (figs. 3, 14 & 21).

Stomata confined to abaxial surface, anomocytic, irregularly distributed, at places contiguous stomata observed cohering pole to pole, 26-30-33 × 13-16-17 μm, stomatal index 32, frequency of stomata 138 per sq. mm.

Trichomes absent but rarely small papillae observed on veins on abaxial surface in *Janardhanan 81694* (fig. 3).

Clematis smilacifolia Wall. *As. Res.* 13 : 402. 1820.

Clematis smilacifolia subsp. **smilacifolia** var. **smilacifolia**

(Dhabraghat, Bastar, 11.2.1961, *N. P. Balakrishnan* & *A. M. Henry 12071*, acc. no. 23775, MH : Minumuburu, Vishakhapatanam, 300 m, 23.12.1967, *G. V. Subbarao 29614*, MH).

Epidermal cells on both surfaces hexa-, or penta-gonal, smooth and thick-walled (fig. 2).

Stomata confined to abaxial surface, anomocytic, irregularly distributed, 30-36-50 × 10-13-15 μm, stomatal index 20-22-25, frequency of stomata 141 per sq. mm.

Clematis smilacifolia ssp. **andamanica** Kapoor, *Kew Bull.* 19 (2) : 331-33. 1965.

(*Balakrishnan* & *Nair 4784*, PBL).

Epidermal cells on both surfaces irregular, sinuous or slightly sinuous (fig. 19).

Stomata confined to abaxial surface, mostly anomocytic, at places paracytic (fig. 19), contiguous stomata frequently observed, 30-34-36 × 15-17-20 μm, stomatal index 17-20-21, frequency of stomata 99 per sq. mm.

Small papillae at places, on adaxial surface mainly on veins, on abaxial surface distributed all over surface.

Clematis fulvicoma Rehd. & Wils. in *Sarg. Pl. Wils.* 1(3) : 327. 1913.

(Kachin Hills, Upper Burma, *Shaik Mukim 1898*, CAL)

Epidermal cells on adaxial surface hexa- or poly-gonal, straight-walled ; on abaxial surface polygonal, straight-walled, elongated on veins.

Stomata confined to abaxial surface, irregularly distributed, anomocytic, contiguous stomata seen occasionally, 30-35-43 × 17-18-20 μm, stomatal index 18-20-24, frequency of stomata 118 per sq. mm.

Trichomes absent.

Clematis andersonii (Cl. ex Ktze.) Hj. Eichler, *Bibl. bot. Stuttgart.* 124 : 47. 1958.

(*W. W. Smith 547*, acc. no. 152, CAL)

Epidermal cells on adaxial surface pentagonal, straight-walled ; on abaxial surface irregular, slightly sinuous.

Stomata confined to abaxial surface, irregularly distributed, anomocytic, 31-34-36 × 17-18-21 μm, stomatal index 22-24-26, frequency of stomata 118 per sq. mm.

Small papillae uniformly distributed on the abaxial surface, base rounded and thick-walled ; trichomes absent on adaxial surface.

Clematis munroiana Wt. *Ill.* 1 : 5. t. 1. 1840.

(Akkamalai, Coimbatore Distt., 1595 m, 23.1.1962, *J. Joseph 13759*, acc. no. 27019, MH).

Epidermal cells on both surfaces irregular, slightly sinuous, on abaxial surface striated at places.

Stomata confined to abaxial surface, irregularly distributed, anomocytic, 36-39-43 × 17-19-21 μm, stomatal index 22-25-28, frequency of stomata 106 per sq. mm.

Striations arising from guard cells.

Small papillae distributed all over the abaxial surface ; trichomes absent on adaxial surface.

Clematis theobromina Dunn, *Kew Bull.* 1914 : 181. 1914.

(Avalanche, Nilgiri Distt., 600 m, 29.12.1970, *B. V. Shetty 37635*, MH).

Epidermal cells on upper surface (fig. 20) penta-, or hexa-gonal, small, straight- and thick-walled ; on abaxial surface (fig. 15) irregular, straight-walled.

Stomata confined to abaxial surface, anomocytic, some surrounded by a number of cells, contiguous stomata seen at places, 30-34-43 × 13-15-17 μ m, stomatal index 19-23-25, frequency of stomata 130 per sq. mm.

Trichomes absent.

Section *Viticella* DC. *emend.* Tamura subsection *Viticella.*

Clematis cadmia Buch.-Ham. (Wall. Cat. 4669, *nom. nud.*) ex Hk. f. & Thoms. *Fl. Ind.* 5. 1855.

(Gorakhpur, Sakhai Forests, 20.3.1920, *Shri Ram 2692,* DD; Bishenpur 900 m, Manipur State, 1.3.1944, *N. L. Bor 18362,* DD; Assam, *Masters s.n.,* MH).

Epidermal cells on adaxial surface irregular smooth-walled; on abaxial surface irregular, slightly sinuous, marginal cells elongated, smooth-walled and slightly thicker than remaining epidermal cells.

Stomata confined to abaxial surface, anomocytic, sparsely arranged (however, *Shri Ram 2692* shows stomata 2-3 cells apart), 26-30-36 × 10-13-17 μ m, stomatal index 27-29-32, frequency of stomata 141 per sq. mm.

DISCUSSION AND CONCLUSION

A critical appraisal of the observations reveals that cuticular features in Indian and related *Clematis* do not conform or correlate to the variation pattern projected by gross morphological features as studied earlier by Kapoor (1962, 1966 and 1983). These exhibit a reticulate pattern in as much as the closely related taxa in several cases possess different cuticular characteristics, and relatively distant ones, nearly similar. This kind of pattern, nevertheless, facilitates in distinguishing various taxa from one another utilising the characters of trichomes, striations, domatia, type of stomata, stomatal index and frequency as well as dimensions, and the epidermal cell walls. To illustrate the above points we may discuss some of the cuticular features as presently studied.

Among the species of section Viorna, whereas *C. connata, C. acuminata* (its 3 subspecies) and *C. tortuosa* have on abaxial surface sinuous epidermal cell walls, the other species, *viz., C. roylei* (both vars.), *C. wattii, C. buchananiana* and *C. grewiiflora* have only slightly sinuous walls. All the species of this groups except *C. tortuosa* have, on adaxial surface, straight walls; in the latter the walls are slightly sinuous. Among these species, *C. connata* and *C. buchananiana* are, however, closer in having paracytic stomata but the two have different kind of trichomes; in *C. connata* the trichome base is round whereas in *C. buchananiana* it is hexagonal. The striations are present only in two species of this section, i.e., *C. buchananiana* and *C. grewiiflora,* whereas, the remaining nine are devoid of these.

Metcalfe & Chalk (1957) described stomata in *Clematis* to be generally anomocytic, confined to abaxial surface, occasionally present on adaxial surface. This is confirmed in the present study but further elaboration of this fact is necessary. The paracytic stomata are present, besides the two species of sect. Viorna, in taxa belonging to other sections also, *viz., C. wightiana* (sect. Meclatis), *C. napaulensis* and *C. montana* (sect. Cheiropsis), *C. puberula* (sect. Clematis) and *C. smilacifolia* ssp. *andamanica* (sect. Naraveliopsis); they are absent in other three species of sect. Meclatis (*C. orientalis, C. graveolens* and *C. vernayi*), two of sect. Cheiropsis (*C. fasciculiflora* and *C. tongluensis*), eight of sect. Clematis (*C. flammula, C. triloba, C. grata, C. gouriana, C. vitalba, C. kerriana* and *C. apiculata*), and six taxa of sect. Naraveliopsis (*C. hedysarifolia, C. smilacifolia* ssp. *smilacifolia, C. fulvicoma, C. andersonii, C. munroiana* and *C. theobromina.*). The two subspecies of *C. smilacifolia, viz.* ssp. *smilacifolia*—the one that is widely distributed and ssp. *andamanica*—the one that is endemic to Andaman & Nicobar Islands—are thus distinguishable, the paracytic stomata being present in the latter. Paracytic stomata, though present in the three infraspecific taxa of *C. montana,* are equally common along with anomocytic ones in *C. montana* ssp. *montana* var. *montana,* paracytic ones more common and anomocytic only occasional in ssp. *montana* var. *manipurensis,* and paracytic taking over completely in ssp. *praecox.* The ssp. *montana* var. *montana* possesses brachyparacytic type also.

The striations are present in species falling in different sections. Besides the two species of sect. Viorna as mentioned above, they are present in *C. wightiana* (sect. Meclatis) ; all the taxa, except *C. montana* ssp. *praecox* of sect. Cheiropsis ; *C. triloba* (sect. Clematis subsect. Pierotianae) ; *C. grata* and *C. vitalba* (sect. Clematis subsect. Vitalbae) ; and *C. munroiana* (sect. Naraveliopsis). They are absent in the remaining four taxa of Meclatis, *C. flammula* (sect. Clematis subsect Pierotianae), four of sect. *Clematis* subsect. Vitalbae and five of sect. *Naraveliopsis.* Their presence in all the taxa of sect. Cheiropsis with the exception of *C. montana* ssp. *praecox* confirms the closer affinity between them. *C. montana* ssp. *montana* var. *montana* is conspicuous in having striations on both the surfaces, whereas ssp. *praecox* is conspicuous by their absence. Contrasting to sect. Cheiropsis, the sect. Naraveliopsis is marked out for the absence of striations in all its taxa except *C. munroiana* which has them on abaxial surface.

The range of stomatal index may be nearly same in all the species of a section *e.g.,* those of sect. Viorna, or different in the various species of the same section. In sect. Bebaenthera, it is of a high order in *C. acutangula* (33-35-37) and of a low order in *C. barbellata* (14-17-22) ; in sect. Cheiropsis, of a high order in *C. napaulensis* (33-35-37), and in others mostly around 20-25——only in *C. montana* ssp. *montana* var. *manipurensis* and *C. montana* ssp. *praecox* it reaches up to 30.

The frequency of stomata also varies irrespective of the sectional groupings based on a combination of gross morphological features which are more or less common within the taxa of each group. It is of a high order (above 200 per sq. mm) in *C. acutangula* (sect. Bebaenthera), *C. napaulensis* (sect. Cheiropsis), and *C. grata* and *C. kerriana* (sect. Clematis). It is of a low order (less than 100 per sq. mm) in *C. barbellata*—sect. Bebaenthera, *C. montana* ssp. *montana* var. *montana*—sect. Cheiropsis, and others.

Stomata are generally present only on abaxial surface but in *C. orientalis* and *C. vernayi*—both of sect. Meclatis, and *C. asplenifolia*—sect. Clematis, they are present on both the surfaces. In other taxa belonging to sects. Meclatis and Clematis they are not present on adaxial surface. The stomatal index as well as frequency of stomata, on adaxial surface is higher in *C. orientalis* var. *obtusifolia* (7-10-11 and 52 respectively) than on the corresponding surface in *C. orientalis* var. *longicaudata* (3-5-7 and 27 respectively).

The presence of domatia in *C. montana* ssp. *montana* var. *montana* (on adaxial surface), and *C. orientalis* var. *obtusifolia* and *C. vernayi* (in both on abaxial surface), distinguishes these from all the other taxa of *Clematis.*

The infraspecific taxa of *C. roylei, viz.,* var. *roylei* and var. *patens* are hard to be distinguished from each other except in width of stomata which ranges from 7 to 12 μm in the former and from 10-13 μm in the latter ; being overlapping even this character is of little taxonomic significance.

C. cadmia (sect. Viticella), which is the only Indian species having beaked achenes—all the rest having achenes with long feathery persistent styles—does not exhibit any remarkable distinguishing cuticular features.

Table 1 : A synopsis of the cuticular features

Name of species	Type	STOMATA Size in (μm) (average)		Stomatal index (average)		Stomatal frequency (per sq. mm)		Epidermal cells		Trichomes		Striations	
		Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Section *Viorna* (Reichb.) Prantl subsect. *Connatae* Koehne													
1. *C. connata* DC.	An. Pa.	34×14	—	26	—	135	—	irregular, sinuous	polygonal to irregular, sometimes hexagonal	abundant on veins, small, papillaelike, base small, round	as on abaxial	—	—
2. *C. acuminata* DC. ssp. *acuminata*	An.	32×12	—	29	—	150	—	highly irregular, sinuous	polygonal, straight	sparsely distributed, base hexagonal	as on abaxial	—	—
3. *C. acuminata* ssp. *sikkimensis* (Hk. f. et Thoms.) Brühl var. *sikkimensis*	An.	29×13	—	29	—	141	—	irregular, sinuous	polygonal, straight	absent, or as on adaxial	few restricted to veins	—	—
4. *C. acuminata* ssp. *andersonii* (Brühl) Kapoor	An.	28×11	—	24	—	106	—	irregular, sinuous	polygonal, straight	long or short, unicellular	as on abaxial	—	—
5. *C. roylei* Rehder var. *roylei*	An.	28×9	—	31	—	164	—	irregular, slightly sinuous	polygonal, straight	more abundant	common, long, unicellular, apex pointed, base hexagonal, slightly thick	—	—
6. *C. roylei* var. *patens* (Haines) Kapoor	An.	28×12	—	31	—	160	—	irregular, slightly sinuous	polygonal, straight	long, unicellular, apex pointed, base hexagonal, more abundant	numerous, long, unicellular, apex pointed, base hexagonal, slightly thick	—	—
7. *C. wattii* Drumm. et Craib	An.	32×14	—	25	—	122	—	irregular, slightly sinuous	penta-, or hexa-gonal, straight	common, bases hexagonal	as on abaxial	—	—

Table I (contd.)

(ii)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
8. *C. tortuosa* (Wall. ex Hk.f. et Thoms.) C. E. C. Fischer	An.	34×14	—	31	—	177	—	irregular, sinuous	penta-, or hexagonal, irregular, slightly sinuous	abundant, long or short, base hexagonal	as on abaxial	—	—
9. *C. buchananiana* DC. var. *buchananiana*	An. Pa.	30×13	—	27	—	136	—	irregular, slightly sinuous	polygonal to irregular	abundant, unicellular, base hexagonal, thick-walled	as on abaxial	+	+
10. *C. grewiiflora* DC. var. *grewiiflora*	An.	28×14	—	29	—	166	—	irregular, slightly sinuous	polygonal, to irregular, straight	longer, frequency much higher than adaxial	numerous, unicellular, long, bases hexagonal, frequently base united	+	+
Sect. *Meclatis* (A. Spach) Tamura subsect. *Orientales* Prantl													
11. *C. orientalis* Linn. var. *longicaudata* (Ledeb.) Boiss.	An.	34×19	—	26	5	112	27	hexa-, or penta-gonal, straight walls thick	as on abaxial	absent, or at times present	absent, or few scattered	—	—
12. *C. orientalis* Linn. var. *obtusifolia* Hk.f. et Thoms.	An.	36×18	—	22	10	105-111	52	irregular, slightly sinuous, (some cells thick-walled)	hexa-, polygonal, straight walls thick	absent, or few scattered	absent	—	—
13. *C. graveolens* Lindl.	An.	33×18	—	18	—	111	—	irregular, slightly sinuous	hexa-, pentagonal, straight	small papillae, sparse, or absent	as on abaxial	—	—
14. *C. wightiana* Wall.	An. Pa.	33×20	—	24	—	161	—	irregular, slightly sinuous, or highly irregular, sinuous	polygonal, straight, or slightly sinuous	more abundant, as on adaxial	common, long, unicellular, apex pointed, base hexa- or pentagonal, slightly thick	+	+

Table 1 (contd.)

(iii)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sect. *Meclatis* subsect. *Tanguticae* Schneider													
15. *C. vernayi* C. E. C. Fischer	An.	32×17	—	21	12	94	54	polygonal, straight	hexa-, or penta-gonal, straight, thick	minute papillae, bases small, round, sparsely distributed	absent	—	—
Sect. *Bebaenthera* Edgew.													
16. *C. acutangula* Hk. f. et Thoms.	An.	32×17	—	35	—	205	—	irregular, sinuous	as on abaxial	small, unicellular, papillae with rounded apex	unicellular, long, with pointed ends, base hexagonal	—	—
17. *C. barbellata* Edgew.	An.	32×14	—	17	—	71	—	slightly sinuous	irregular, very slightly sinuous	absent, or few, scattered	absent, or few, scattered	—	—
Sect. *Cheiropsis* DC.													
18. *C. napaulensis* DC.	An. Pa.	18×11	—	35	—	218	—	irregular, slightly sinuous	irregular, smooth	short, unicellular, many, base rounded	short, unicellular, mostly on veins	+	—
19. *C. fasciculiflora* Franchet	An.	38×14	—	22	—	97	—	sinuous	irregular, slightly sinuous	few, scattered	few, scattered	+	—
20. *C. montana* Buch.-Ham. ex DC. ssp. *montana* var. *montana*	An. Pa. Bpa.	34×18	—	18	—	74	—	polygonal, smooth	penta-, or hexa-gonal, thick, smooth	present more on veins	present more on veins	+	+
21. *C. montana* ssp. *montana* var. *manipurensis* Brühl	Pa. An.	28×14	—	26	—	107	—	irregular, slightly sinuous	irregular, slightly sinuous, thickened	short glandular, base small, hexagonal, only on veins	numerous, short, glandular, base small, hexagonal, mostly on veins	+	—
22. *C. montana* ssp. *praecox* Ktze.	Pa.	28×12	—	28	—	144	—	irregular, slightly sinuous	sometimes elongated	mostly short	short and long both, base rounded	—	—

Table 1 (contd.) (iv)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
23. *C. tongluensis* (Brühl) Tamura var. *tongluensis*	An.	28×14	—	22	—	—	—	usually polygonal, straight	penta-, hexa, or polygonal, thick, arched or straight	unicellular papillae, scattered all over surface	on veins, scattered, apex rounded, base rounded	+	—
Sect. *Clematis* subsect. *Pierotianae* (Tamura) Tamura													
24. *C. flammula* Linn.	An.	30×18	—	26	—	106	—	polygonal, slightly sinuous	usually polygonal smooth, slightly thick	scattered or absent	few, scattered	—	—
25. *C. triloba* Heyne	An.	38×23	—	26	—	112	—	irregular, slightly sinuous	polygonal or irregular, smooth	long, unicellular, some small, papillae-like	long, unicellular, base small, circular, thick-walled	+	—
Sect. *Clematis* subsect. *Vitalbae* (Prantl) Tamura													
26. *C. puberula* Hk. f. et Thoms.	An. Pa.	29×12	—	21	—	106	—	irregular, slightly sinuous	as on abaxial	unicellular, short, base hexa-gonal, thick-walled	as on abaxial but more abundant	—	—
27. *C. grata* Wall.	An.	40×19	—	39	—	284	—	irregular, sinuous	quite irregular, slightly sinuous	long, on veins, short distributed all over, base hexa-gonal	long, unicellular, base hexagonal, thick-walled, small one-celled papillae	+	—
28. *C. gouriana* Roxb. ex DC.	An.	32×15	—	23	—	125	—	irregular, sinuous, or polygonal, straight sometimes, slightly sinuous	irregular, slightly sinuous	numerous on veins, long, unicellular, base small, rounded	as on abaxial, scattered few or absent	—	—
29. *C. vitalba* Linn.	An.	34×17	—	25	—	121	—	irregular, sinuous	as on abaxial	—	on larger veins only, sparse, small papillae	+	—

Table 1 (contd.)

(v)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
30. *C. kerriana* Drumm. et Craib	An.	29×11	—	41	—	217	—	irregular, sinuous	penta-, to hexa-gonal, at places irregular, slightly sinuous	as on adaxial	unicellular, long or short, papillae-like, base hexa-gonal, thick-walled, more abundant on veins	—	—
31. *C. apiculata* Hk. f. et Thoms.	An.	29×13	—	27	—	129	-	irregular, slightly sinuous	hexa-, or penta-gonal, straight	unicellular, long	unicellular, long, on veins only	—	—
Sect. *Clematis* subsect. *Rectae* Prantl													
32. *C. asplenifolia* Schrenk	An.	34×15	33×26	23	11	80—120	39	hexa-, or pentagonal, straight	as on abaxial	absent	absent	—	-
Sect. *Naraveliopsis* Hand.-Mzt.													
33. *C. hedysarifolia* DC.	An.	30×16	—	32	—	138	—	irregular, sinuous	penta- or hexa-gonal, straight or irregular, slightly sinuous	rarely small papillae on veins	absent	—	—
34. *C. smilacifolia* Wall. ssp. *smilacifolia* var. *smilacifolia*	An.	36×13	—	22	—	141	—	hexa-, or penta-gonal, smooth, thick	as on abaxial	absent or few scattered	absent	—	—
35. *C. smilacifolia* ssp. *andamanica* Kapoor	An. Pa.	34×17	—	20	—	99	—	irregular, sinuous or slightly so	as on abaxial	small papillae	small papillae mainly on veins	—	—
36. *C. fulvicoma* Rehd. et Wilson	An.	35×18	—	20	—	118	—	polygonal, straight, elongated on veins	hexa-, or poly-gonal, straight	absent	absent	—	—
37. *C. andersonii* (Clarke ex Ktze.) Hj. Eichler	An.	34×18	—	24	—	118	—	irregular, slightly sinuous	pentagonal, straight	small papillae, base rounded thick-walled	absent	—	—

Table I (contd.) (*vi*)

1	2	3	4	4	6	7	8	9	11	12	12	13	14
38. *C. munroiana* R. Wight	An.	39×19	—	25	—	106	—	irregular, slightly sinuous	as on abaxial	small papillae, distributed all over	absent	+	—
39 *C. theobromina* Dunn	An.	34×15	—	23	—	130	—	irregular, straight	penta-, or hexagonal, straight, thick	absent	absent	—	—
Sect. *Viticella* DC. *emend.* Tamura subsect. *Viticella*													
40. *C. cadmia* Buch.-Ham. ex Hk. f. et Thoms.	An.	30×13	—	29	—	141	—	irregular, slightly sinuous	irregular, smooth	present	present	—	—
Genus : *NARAVELIA*													
41. *Naravelia zeylanica* (Linn.) DC.	An.	39×15	—	26	—	121	—	irregular, slightly sinuous	as on abaxial	common on margin only, small papillae, base small, hexa-gonal	as on abaxial	—	—

An., anomocytic ; Bpa., brachyparacytic : Pa., paracytic ; +, present : —, absent

Key based on characteristics of leaf cuticle

1a Striations present
2a Striations present on both surfaces
3a Paracytic stomata absent .. *C. grewiiflora* var. *grewiiflora*
3b Paractytic stomata present
4a Brachyparacytic stomata and the contiguous ones present .. *C. montana* ssp. *montana* var. *montana*
4b Brachyparacytic stomata and the contiguous ones absent
5a Width of stomata 13 μm, frequency 136 per sq. mm .. *C. buchananiana* var. *buchananiana*
5b Width of stomata 17-20 μm, frequency 161 per sq. mm .. *C. wightiana*
2b Striations present only on abaxial surface
6a Paracytic stomata present
7a Epidermal cell walls on abaxial surface straight, stomatal index not more than 24 *C. tongluensis* var. *tongluensis*
7b Epidermal cell walls on abaxial surface sinuous or slightly so, stomatal index usually more than 24
8a Frequency of stomata 218 per sq. mm, dimensions 17-18-20 × 10-11-13 μm, index 33-35-37, anomocytic common, paracytic occasional domatia absent .. *C. napaulensis*
8b Frequency of stomata 107 per sq. mm, dimensions 26-28-29 × 13-14-17 μm, index 24-26-28, paracytic common, anomocytic occasional, domatia present on adaxial surface .. *C. montana* ssp. *montana* var. *manipurensis*
6b Paracytic stomata absent
9a Stomatal index above 35, frequency 284 per sq. mm .. *C. grata*
9b Stomatal index not more than 30, frequency not more than 125 per sq. mm
10a Twin stomata present .. *C. triloba*
10b Twin stomata absent
11a Trichomes absent on adaxial surface .. *C. munroiana*
11b Trichomes present on adaxial surface
12a Collapsed guard cells in stomata present, frequency 121 per sq. mm *C. vitalba*
12b Collapsed guard cells absent, frequency 97 per sq. mm .. *C. fasciculiflora*
1b Striations absent
13a Paracytic stomata present
14a Anomocytic stomata absent .. *C. montana* ssp. *praecox*
14b Anomocytic stomata present
15a Twin stomata absent .. *C. puberula*
15b Twin stomata present
16a Stomatal index 22-26-29, frequency 135 per sq. mm .. *C. connata*
16b Stomatal index 17-20-21, frequency 99 per sq. mm .. *C. smilacifolia* ssp. *andamanica*
13b Paracytic stomata absent
17a Stomata present on both surfaces
18a Twin stomata present
19a Domatia absent, frequency of stomata on adaxial surface 39 per sq. mm .. *C. asplenifolia*
19b Domatia present on abaxial surface, frequency of stomata on adaxial surface 52 per sq. mm .. *C. orientalis* var. *obtusifolia*
18b Twin stomata absent
20a Stomatal index on adaxial surface 3-5-7, domatia and trichomes absent, frequency of stomata on adaxial surface 27 per sq. mm .. *C. orientalis* var. *longicaudata*
20b Stomatal index on adaxial surface 10-12-13 ; domatia and trichomes present on abaxial surface, frequency of stomata on adaxial surface 54 per sq. mm .. *C. vernayi*
17b Stomata present only on abaxial surface
21a Twin stomata present
22a Cytoplasmic connections between stomata at places .. *C. flammula*
22b Cytoplasmic connection between stomata not present
23a Trichomes on adaxial surface with base hexagonal .. *C. acutangula*
23b Trichomes on adaxial surface absent, if present then with base round
24a Trichomes on abaxial surface long, numerous on veins .. *C. gouriana*
24b Trichomes on abaxial surface absent, if present then small papillae
25a Epidermal cells on abaxial surface sinuous, stomatal index 32 .. *C. hedysarifolia*

25b Epidermal cells on abaxial surface straight, stomatal index less than 26
26a Stomatal frequency 130 per sq. mm, width of stomata 13-15-17 μm .. *C. theobromina*
26b Stomatal frequency 118 per sq. mm, width of stomata 17-18-20 μm. .. *C. fulvicoma*
21b Twin stomata absent
27a Stomatal index not more than 20 (except for the highest figure of the range 22 in *C. barbellata*)
28a Epidermal cell walls on adaxial surface straight, stomata 17-18-21 μm wide, frequency 111 per sq. mm .. *C. graveolens*
28b Epidermal cell walls on adaxial surface slightly sinuous, stomata 12-14-17 μm wide, frequency 71 per sq. mm .. *C. barbellata*

27b Stomatal index more than 20 (except for the lowest figure of the range being 20 in *C. wattii* and *C. smilacifolia* ssp. *smilacifolia*)
29a Trichomes present on entire adaxial surface
30a Stomatal index 37 or more (37-41-46), frequency 217 per sq. mm .. *C. kerriana*
30b Stomatal index less than 37(29-36), frequency much less than 200 per sq. mm
31a Epidermal cell walls on abaxial surface sinuous, frequency of stomata 177 per sq. mm .. *C. tortuosa*
31b Epidermal cell walls on abaxial slightly sinuous, frequency of stomata less than 170 per sq. mm
32a Frequency of stomata 122 per sq. mm .. *C. wattii*
32b Frequency of stomata 160-164 per sq. mm .. *C. roylie*
29b Trichomes on adaxial surface absent, or present on veins only except rarely on entire surface in *C. acuminata* ssp. *andersonii* or also on margins in *C. cadmia*
33a Epidermal cell walls on abaxial surface sinuous
34a Giant stomata present, stomatal index 22-24-29, frequency 106 per sq. mm .. *C. acuminata* ssp. *andersonii*
34b Giant stomata absent, stomatal index 26-29-35, frequency above 140 per sq. mm
35a Frequency of stomata 141 per sq. mm .. *C. acuminata* ssp. *sikkimensis*
35b Frequency of stomata 150 per sq. mm .. *C. acuminata* ssp. *acuminata*
33b Epidermal cell walls on abaxial surface slightly sinuous
36a Frequency of stomata of the order of 140 per sq mm
37a Stomatal index 20-22-25, length 30-36-50 μm .. *C. smilacifolia* ssp. *smilacifolia*
37b Stomatal index 27-29-32, length 26-30-36 μm .. *C. cadmia*
36b Frequency of stomata of the order of 130 per sq. mm
38a Trichomes absent on adaxial surface, small papillae present on abaxial surface, stomatal index 22-24-26, frequency 118 per sq. mm, dimensions 31-34-36× 17-18-21 μm .. *C. andersonii*
38b Trichomes long, present on both surfaces, stomatal index 24-27-32, frequency 129 per sq. mm dimensions 26-29-30 ×10-13-15 μm .. *C. apiculata*

The same is true of *Naravelia zeylanica* (cuticular data included in Table 1 only) which is characterised by twisted achenes and leaflet-tendrils. Incidentally both of these are regarded as advanced taxa.

It has been endeavoured to present in Table 2 an artificial key based on exclusively cuticular features, to distinguish the various taxa of *Clematis* studied here. These characters are to be used, however, with caution as have been found variable within the same species. For instance, in *C. hedysarifolia* collected from two different localities the epidermal cell walls on adaxial surface have been seen to be respectively straight and slightly sinuous. In *C. wightiana* collected from one locality the epidermal cell walls on adaxial and abaxial surfaces are straight and slightly sinuous respectively, but in that from another locality they are respectively slightly sinuous and distinctly sinuous. In *C. flammula* the dimensions of stomata are highly variable in the same specimen. The common ones are 26-30-33 × 17-18-20 μm whereas the occasional ones are 36-38-40 × 23-24-26 μm ; the transition in dimensions is gradual and, therefore, the latter kind cannot be termed as giant stomata.

It may thus be concluded that the cuticular features in *Clematis* should be utilised for the purpose of systematics preferably in combination with other characters of gross morphology.

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